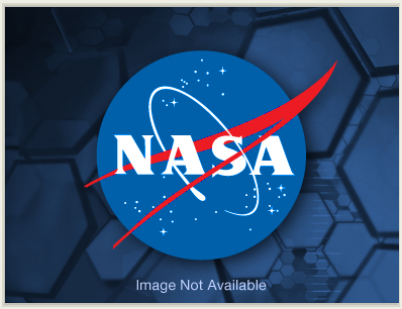
Development of computational infrastructure to support hyper-resolution large-ensemble hydrology simulations from local-to-continental scales

Completed Technology Project (2015 - 2017)

Project Introduction

Development of computational infrastructure to support hyper-resolution large-ensemble hydrology simulations from local-to-continental scales A move is currently afoot in the hydrologic community towards multi-model ensembles to capture the substantial uncertainty in environmental systems. However, the current generation of operational and experimental simulation platforms can be characterized as 'small ensemble' systems. Typically, fewer than five hydrologic models are used to characterize model uncertainty, and the multi-model systems have a poor probabilistic portrayal of risk. As a result, water resource management decisions based on these 'small ensemble' systems will often be suboptimal and in the worst case will simply be wrong. The relatively small size of the ensembles in current multi-model systems is largely dictated by the considerable difficulty and human resources needed to implement and parameterize individual hydrological models so that they can be operated within a common framework. We have developed an advanced hydrologic modeling approach, SUMMA (the Structure for Unifying Multiple Modeling Alternatives), which enables explicitly representing the ambiguities in a myriad of modeling decisions. SUMMA can be used to design ensemble systems with specific properties and improve the probabilistic characterization of risk. SUMMA is currently at Technical Readiness Level 3, and focused effort on computational infrastructure is necessary to develop the next-generation modeling system needed to support water resources planning and management throughout the USA. The goal of this project is to develop the computational infrastructure to enable hyper-resolution large-ensemble hydrology simulations from local-to-continental scales. By hyper-resolution we mean hydrology simulations on spatial scales of the order of 1 km and by large ensemble we mean a multi-model ensemble of the order of 100 ensemble members. The continental-scale domain for this project is the contiguous USA. The goal of hyper-resolution, large-ensemble, continental-domain hydrology simulations will be accomplished with focused effort on the following four tasks: (1) Satisfy data requirements of multiple modeling approaches (e.g., spatial parameter fields); (2) Improve SUMMA's numerical robustness and computational efficiency; (3) Embed SUMMA in the NASA Land Information System (NASA-LIS) to expand multi-model simulation capabilities; and (4) Evaluate and refine the multi-model ensemble. These tasks represent the obvious next steps to advance probabilistic continental-domain modeling capabilities at spatial scales relevant for water managers. The first two tasks of fulfilling data requirements for multiple modeling approaches and improving the computational performance of hydrologic models is necessary to enable hyper-resolution, large-ensemble, continental-domain hydrology simulations. The third task of embedding SUMMA in NASA-LIS takes advantage of NASA's state-of-the-art multi-model framework, especially its ensemble modeling and model benchmarking capabilities. It also extends the capabilities of NASA-LIS to support large multi-model ensembles. The final task to evaluate and refine the multi-model ensemble is necessary to



Development of computational infrastructure to support hyper-resolution large-ensemble hydrology simulations from local-to-continental scales

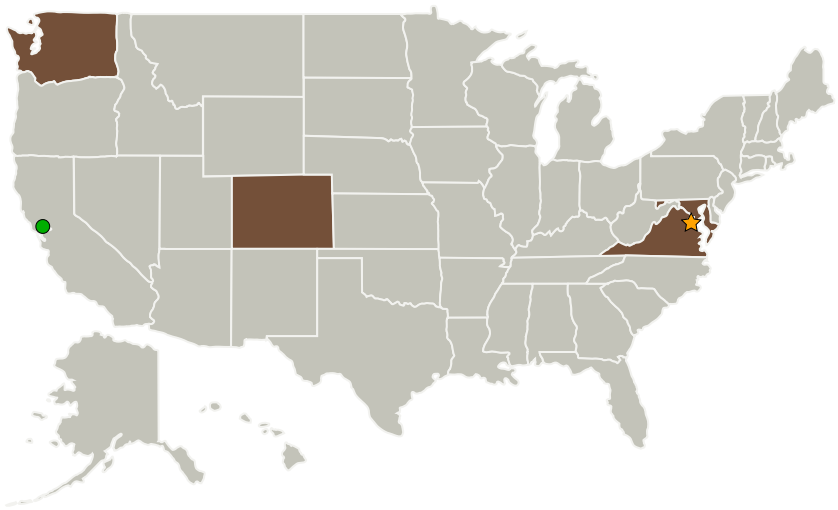
Table of Contents

Development of computational infrastructure to support hyper-resolution large-ensemble hydrology simulations from local-to-continental scales

Completed Technology Project (2015 - 2017)

improve the probabilistic characterization of risk. By using a common modeling core in SUMMA, the overhead associated with implementing alternative modeling approaches is significantly reduced, a major departure from current 'small ensemble' methods. By embedding SUMMA within NASA's Land Information System (LIS), meaningful 'large ensemble' systems will become a reality and can provide improved guidance for water resource management decisions by our development partners at the U.S. Army Corps of Engineers and the Bureau of Reclamation.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★NASA Headquarters(HQ)	Lead Organization	NASA Center	Washington, District of Columbia
●Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California
National Center for Atmospheric Research(NCAR)	Supporting Organization	R&D Center	Boulder, Colorado

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Center / Facility:

NASA Headquarters (HQ)

Responsible Program:

Advanced Information Systems Technology

Project Management

Program Director:

Pamela S Millar

Program Manager:

Jacqueline J Le Moigne

Principal Investigator:

Martyn P Clark

Co-Investigators:

Virginia L Taberski
David J Gochis
Levi Brekke
Christa D Peters-lidard
J Arnold
Bart Nijssen

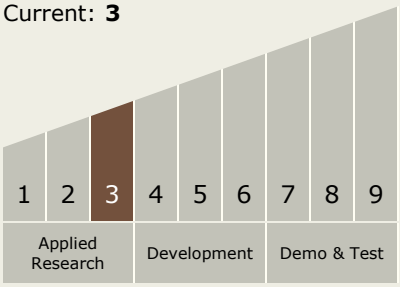
Development of computational infrastructure to support hyper-resolution large-ensemble hydrology simulations from local-to-continental scales

Completed Technology Project (2015 - 2017)

Primary U.S. Work Locations	
Colorado	Maryland
Virginia	Washington

Technology Maturity (TRL)

Start: **3**
Current: **3**



Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.3 Simulation
    - TX11.3.5 Exascale Simulation

Target Destination

Earth